its glass the flame is drawn downwards by a powerful current of air which circulates in a lower pipe to which the tube B is fitted. Owing to the draught the burner does not become heated, and the hand may be placed upon it without being burnt; the robe of a dancer may without danger brush it, since the flame is produced in an enclosed space. If the glass A is accidentally broken, the burner E, mounted on a pivot, is lowered at C, and by this movement sets in motion a small valve, which shuts off the gas, and the light is thus put out. The jets of the footlights are arranged in series of twelve, and number in all 120. These 120 lights may be raised to the height of the stage, or lowered underneath the prompter's hole, below the flooring of the front stage, by a mechanism which draws them all together, and which two men can easily move.

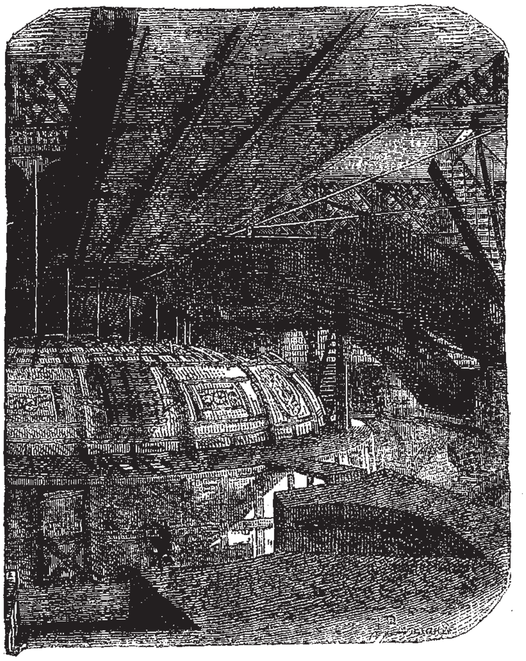

FIG. 3.—Ventilating Apparatus of the New Opera. (From M. Nuitter's work.)

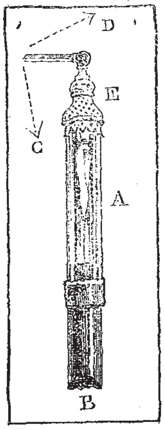

FIG. 4.—Gas-jet, with reversed flame, used in the footlights of the New Opera

By a very ingenious arrangement all the lights in the theatre can be lowered suddenly so as to produce a night-effect, without the least danger of any of them being extinguished.

One of the most important applications of science in the New Opera is the use made of electricity, which we shall describe in another article.

(*To be continued.*)

ENGLISH GOVERNMENT ECLIPSE EXPEDITION, 1875

INSTRUCTIONS TO OBSERVERS.*

1.—*Spectroscopic Observations—Objects to be attained.*

THE objects to be attained are mainly the determination, so far as may be possible, of the chemical constitution of the chromosphere and of the coronal atmosphere; of the height to which the various vapours extend from the photosphere, and of the order in which they thin out. It is anticipated that the chromosphere, at all events, may be very rich in ultra-violet rays. The solar spectrum has already been photographically compared with metallic vapours from G some distance outwards. The operations, therefore, will be mainly photographic, glass being employed as little as possible to produce the necessary dispersion, and replaced by quartz. The attack is twofold, spectroscopes being used in conjunction with telescopes for obtaining line spectra, and prismatic cameras being employed for the purpose of obtaining images of the chromosphere and coronal atmosphere built up by the rays emitted by its various constituents. The prismatic camera will probably give the best results with regard to the height and order of the various layers, while the general nature of the spectrum beyond H, *i.e.* whether it is continuous, channel-spaced, or lined, will be best determined by the ordinary spectroscopes.

Adjustment of Spectroscopes.

Take out camera, and determine focal point for blue rays by receiving image of sun on ground glass, and by using solution of sulphate of copper in ammonia in front of object-glass. (The strength of solution to be determined beforehand such that no light less refrangible than G should pass at all, and that the centre of gravity of spectrum is H, or outside it.)

To determine focus of collimator, reinsert camera and move sliding portion of collimator attached to slit-plate till the lines of the spectrum at or outside H are clearly defined.

All prisms to be set for minimum deviation of H.

To find proper distance of slit-plate from telescope, throw image of sun on, so as to cover half the slit, and adjust the spectroscope to such a distance that the boundary of the spectrum of the photosphere at H is perfectly hard.

Photographs should be employed for ascertaining the focus; the slits to be clean, and adjusted so that at least three lines be seen between the two H's. No photograph need be examined which will not bear a magnifying power of ten times. It must be remembered that a difference of 1-1000th of an inch is of importance in such adjustments. The best definition with the dispersion employed will be attained when the line in the middle between the H lines is seen double.

The hardness of the sun's limb to be determined photographically in the same manner.

If power to incline the plate is obtained, the part of the plate to receive the more refrangible rays will, of course, be nearer to objective of camera, as in the case of all non-achromatic lenses. The angle to be determined by experiment. The spectrum should fall on the plate so that G falls close to one edge, the central and other portions of the plate being reserved for the more refrangible end of the spectrum.

Care must be taken that the axes of the collimator and of the telescope be coincident.

Adjustment of Prismatic Camera.

This instrument is to be adjusted like an ordinary spectroscope by means of collimator placed in front of its prism. By application of external collimator, the prism is to be set to minimum deviation of H, the hydrogen line near G falling near one edge of the plate.

Before this instrument is put on the telescope, the prism thus adjusted should be taken off and perfect parallelism of the tubes obtained by observing the images of the sun or star.

The subsequent inclination of the two axes will be determined by taking photographs of spectrum with or without a collimator, so that ring corona near G will be the least refrangible portion of spectrum on plate, while the sun falls on the steel plate of the telescope to which the prismatic camera is attached. Care should be taken that the least refrangible part of the ring corona should be recorded. The axis of the camera should *cut* the axis of the declination axis.

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* Drawn up by the Eclipse Committee of the Royal Society.

Observations to be made with Telespectroscopes.

Before and after totality the *cusps* should be continually thrown on the slit and the spectrum photographed; long exposures should be at first employed. At least one spectrum of the sun should be obtained before totality, with the ordinary position of the plate, in order to indicate the parts of the plate on which the various parts of the spectrum falls with the angle of deviation and the orientation adopted.

In all instruments just previous to totality, the vanishing portion of sun is to be used to obtain a scale on the plate on which the attempt will be made to obtain the spectrum of Young's stratum, and the other phenomena at the beginning of totality.

For this purpose one of the end windows will be opened, and all the others closed in the first instance, the open part of the slit being arranged radially over that portion of the sun's light which will be the last to disappear. Immediately before totality all the windows are to be opened without deranging the instrument.

The time for which the plates are to be exposed after the commencement of totality will be subsequently referred to.

For observation at end of totality all windows except one at the end of slit to be opened. The part of the sun which will first reappear should lie on the slit just outside the closed shutter (the motion of the moon being taken into account), so that the phenomena at moment of reappearance may be photographed. Immediately after reappearance the previously opened shutters should be closed, and the previously closed shutter should be opened to obtain the solar spectrum as a scale. Care should be taken not to confound the brighter parts of the chromosphere, at reappearance, with the sun itself.

Observations with the Prismatic Camera.

A trial photograph can be made when 1-100th part of sun's diameter is still visible. The results of development of the spectrum of the two cusps should determine the time of exposure before totality; as many photographs should be obtained as possible before totality, being rapidly multiplied just before disappearance. The number of plates to be taken during totality to be subsequently referred to. The number of plates to be obtained after totality will depend on results of development before totality.

2. *Observations on the Polarisation of the Corona.*

The primary object of these observations was to furnish evidence on the question whether the corona was a true solar phenomenon, or in some way due to a glare in the terrestrial atmosphere. In the former case the position of the plane of polarisation (if the light were polarised at all) would have reference to the sun's centre, and would be parallel or perpendicular to a line joining the centre to the point observed. In other words, the polarisation would be radial. In the latter case it would have reference to the general direction of the observers' view; *i.e.* it would be uniform over the whole area of the corona.

Former observations appear to show that the total light from the corona is partly polarised; and that the polarisation is in part radial, and in part unidirectional. In addition to this, spectroscopic observations have connected the corona with the sun. But, although the main question may consequently be considered as already settled, the polariscopic observations have been found so delicate as to justify their repetition. The details of polarisation, if sufficiently well defined, may tell us something of the condition of the matter emitting coronal light; and if to former eye observations photographic pictures be added, our information may be extended to regions further from the sun's surface than any of which we have at present cognisance.

If a Nicol's prism be placed in the tube of a telescope of long focus (*i.e.* in which the convergence of the rays from the object-glass is not so great as perceptibly to affect the analysing power of the Nicol), then, on turning the Nicol so as to cut off the part of the light polarised in one plane, we shall see only that which is radially polarised together with the unpolarised light.

The part of the light polarised radially would, without an analyser, appear as a complete ring of light, except so far as it is interrupted by rifts or other irregularities; but with the Nicol the ring will appear divided into two halves, brightest at the points where the radial polarisation coincides with that due to the Nicol, and shading down to the intensity of the unpolarised light alone at points situated 90° from the former.

In other positions of the Nicol the atmospheric polarisation will be less and less suppressed; and at a position 90° from its first, it will retain its full relative intensity.

A quartz or a biquartz might, of course, be used, but with feeble light the eye is better able to distinguish between differences of intensity than between differences of colour.

To use the instrument sent out. On the day before the eclipse, take out the eye end containing the Nicol and camera and turn the Nicol, till the bottom of the camera being horizontal, the light reflected at the polarising angle, from a polished mahogany surface is cut off.

The first photograph should be taken with the instrument so adjusted, and the camera and Nicol must be inserted in the telescope so that the top and bottom of the plate are horizontal when the telescope is directed to the sun.

The first photograph to be exposed for 25 seconds.

Between each photograph the camera and Nicol to be rotated through 30° in the direction of the hands of a watch.

It is desirable that some of the exposures should be long, as by this means the extent of the corona can be best determined.

If the development shows that it may be attempted with advantage, one or two photographs may be taken with very short exposures.

The adjustment of this instrument to the blue rays must be most carefully determined beforehand, as the object glass is not corrected for them.

GENERAL REMARKS.

Plates during Totality.

The number will depend upon experiments to be made on the rapidity of drying and decrease of sensibility. If it is found that plates may be exposed during the whole of totality, some plates at least should be exposed for the whole of that time. In prismatic camera, one may be exposed for one minute to begin with. Whether the next plate should be exposed during two or three minutes to depend on results of development.

Width of Slit.

Arrangements should be made for readily securing the opening of slit which gives the best testing effect referred to before, and a wide opening which allows at least one line being seen between the H's, can be readily distinguished. This latter opening should be used in all observations during totality. For scale determinations the first position of slit should be employed. In some instruments a much wider slit may be used than in others. Experiments should be made on this point.

Precautions to be attended to in preliminary experiments.

1. All apertures to be reduced. The slit should not be exposed longer than necessary to the heating power of the sun.

2. Object-glasses and mirrors not to be unscrewed from their cases till telescopes are perfectly mounted.

Precautions to be attended to half an hour before Totality.

1. If an aperture has been reduced for preliminary experiments, take care that full apertures are restored.
2. In case any telescopes are used for eye observations, reminder should be given to take off dark glasses before totality.
3. Wind up all clocks.
4. Let all strangers withdraw.
5. Light lamps.

Arrangement of Photographic Plates.

As the plates are smaller than was intended, the spectrum must be thrown along the length of the plate, and if possible, in the prismatic cameras, from corner to corner.

A shelf should be prepared over the developing table with places marked 1, 2, 3, &c. The backs used in any one instrument should be labelled in large letters on both sides, and a similar label should distinguish each shelf. The plates will then arrange themselves into series, and can be numbered afterwards. Care must be taken to have lamps in the dark room.

The Time Teller.

One person should be detailed at each station to tell the time.

The chief observer at each station will give the signal for commencement for totality, which being done, the time assistant will call out the number of seconds of calculated duration at the locality. If, for instance, the totality is four minutes, he will say "You have 240 seconds," and go on calling out every ten seconds the number of seconds still left for work. A clever man can do this in a very encouraging way. The time counter should take care not to distract himself by losing sight of the face of the watch or chronometer, and it is to be impressed upon him that much of the success of the observations will depend on his undivided attention, as his statement of time will be an order to the observers to do certain work.

Rehearsals.

There must be at least two complete rehearsals of the whole attack on two previous days at the time of the eclipse, and the final written instructions to each observer given by the chief of the party will mainly depend on the experience of these rehearsals, which must be of a very serious character. It must be recollected that the speed and skill in collodionising and developing can only be thus determined.

The going of the clocks and counterpoising of telescopes in the particular position in which they will be employed near the time of totality must be examined with the greatest care, and the best regulation of the clock for this position should be adhered to. In these rehearsals all apertures must be reduced.

The clock weights must also be examined, and increased if necessary to produce an uniform motion of the telescope.

Silence.

Silence must only be broken by the timekeeper. The rehearsals should be utilised for asking any questions touching any part of the duties of each observer during the observations, and each observer should have his programme of work nailed up where it can be easily seen.

In order to prevent noise and interruptions, none but the observers and trained assistants should be allowed to be within fifty yards of the observatories, for an hour before and an hour after totality.

Programme of Work.

The Programme of Work may conveniently be stated in the time called out by the time observers. In which case "200 seconds more," and so on, will become an instruction to one of the observers to do a particular piece of work.

Notes on the Phenomena Observed.

Anything an observer has to record should be done immediately after totality, or the last observation after totality.

Trust nothing to memory; a note made the next day will be comparatively valueless.

Multiplication of Results.

As soon as convenient after the eclipse, before leaving the station, at least four copies of every photograph must be made, and enlargements, if possible, in duplicate on glass. Paper copies of these duplicates should be transmitted by two different mails to the Royal Society. The various copies to be sent home if possible by different mails and different routes. One copy to be left in India and given in charge of the chief of the Indian expedition.

Photographs of the Corona.

It will be very desirable for the observers appointed by the Indian Government to depict photographically the corona as a whole, to take some photographs on plates so placed in the long focus camera (rectilinear lens) that the back of the plate is towards the object-glass and the collodion towards the observer, in order to avoid reflection from the second surface of the glass. Special plate holders will have to be made, and the glass selected as perfect as possible and of nearly the same thickness. Of course the back must be carefully cleaned before the plate is exposed.

Observations to be reduced by the Royal Society.

It is understood that the observations made by the members of the English Expedition are the property of the Royal Society, by which body they will be reduced. It is hoped that the Indian Government will allow duplicates of the observations taken by the Indian parties to be forwarded to the Royal Society to aid in these reductions, and to enable a general account of the whole attempt to be prepared. The English observers detailed to India will co-operate with the Chief of the Indian station to which they may go, and will assist in carrying out the arrangements in accordance with the foregoing instructions.

All experiments made for the furtherance of the objects of the expedition will be carefully recorded and will be considered the property of the Royal Society.

SCHOLARSHIPS AND EXAMINATIONS FOR NATURAL SCIENCE AT CAMBRIDGE, 1875

THE following is a list of the scholarships and exhibitions for proficiency in Natural Science to be offered at the several Colleges and for non-collegiate students in Cambridge during the present year:—

Trinity College.—One or more scholarships of 100*l.*, and one exhibition of 50*l.* The examination for these will commence on March 30. Further information may be obtained from the Rev. E. Blore, Tutor of Trinity College.

St. John's College.—One of the value of 50*l.* per annum. The examination (in Chemistry, Physics and Physiology, with Geology, Comparative Anatomy, and Botany) will commence on April 3, and will be open to all persons who have not completed a term of residence at the University, as well as to all who have entered and have not completed one term of residence. There is a separate examination in Natural Science at the time of the annual College examination at the end of the academical year, in